



Joint Seabased Theater Access Workshop

Duck, NC
8-10 February 2005

Deep Water Stable Craneship

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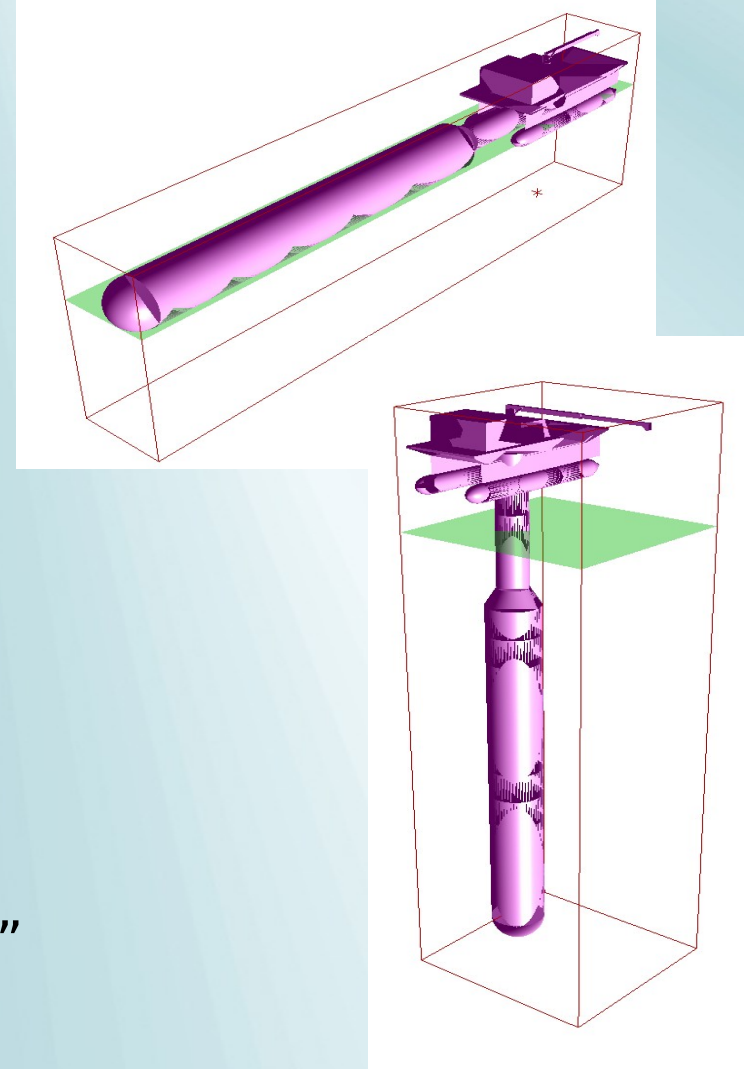
ACKNOWLEDGEMENTS

- **ONR** : RADM J Cohen
- **CISD Seabasing Innovation Cell** : original members Feb-May 03
 - **Dr Colen Kennell** : original idea
 - **Michael Gilbertson** : spar sizing and initial design
 - **Jerry Sikora** : x-Code 6500, preliminary spar structural design
 - **Tim Smith** : Code 5500, Seakeeping
- **Dan Jacobs** : catamaran design
- **ONR NREIP students** : Gena Johnson, Jamie Graham and Paul Morriseau : hinge and connector design, animation
- **UK MOD & DESG** : Exchange Officer & Graduates
- **FAU OE Dept** : 1:15 scale 'Demonstrator'



AGENDA

1. Current practice
2. Sea Basing challenges
3. Spar technology
4. Deep Water Stable Craneship
 - Design development
 - Performance assessment
 - Alternative uses
5. FLIPSHIP-II
6. FAU 1:15 scale "Demonstrator"





CURRENT MATERIEL TRANSFER





Current at-sea container transfer...



Note:

1. Size of the craneship
2. Size of cranes
3. Seastate (benign)



SEA BASING CHALLENGES

MATERIEL

- At-sea transfer of TEUs through seastate
- Quantities / rates / types / packaging / selectivity
- Interface with commercial / allied shipping



Weight : ~ 15 tons
Size : 20' x 8.5' x 8'

current limit

goal

Seastate (Open Ocean N Atlantic)	Significant Wave Height	Sustained Wind Speed	Modal Wave Period
2	0.1 - 0.5m	7 - 10 kts	3.3 - 12.8 secs
4	1.25 - 2.5m	17 - 21 kts	6.1 - 15.2 secs

TEU : Twenty-foot Tonnage Equivalent Unit (i.e. Shipping Containers)



MARINE EXPEDITIONARY BRIGADE (MEB)

DAILY DEMANDS	
Materiel	ST/day
WATER	190
CARGO FUEL	225
DRY STORES	
- Food	15
- Ammunition	33
- Other ¹	27
Sub-total (liquids)	415 ST/day
Sub-total (dry stores)	75 ST/day
TOTAL	490 ST/day¹

MEB ~13,000 troops
6,800 troops ashore / 6,200 float



Materiel demands for troops

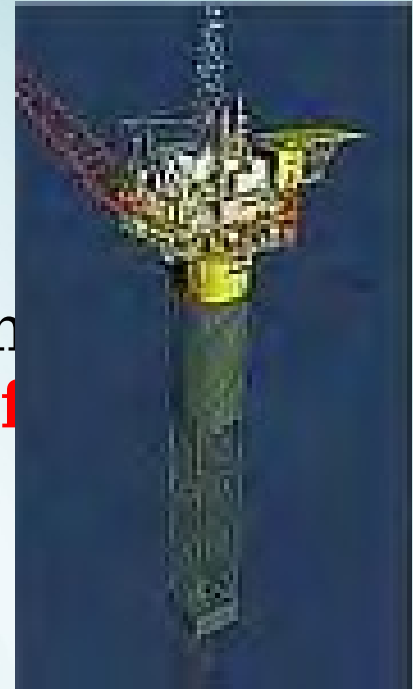
ashore
~ 30 to 70 TEU / day
(just for the shore based MEB)

¹. May increase to **1,000 ST/day** depending on OP-TEMPO



SPAR TECHNOLOGY

- Significant offshore use / experience
- Superior seakeeping
- Little or no Military experience
- Lack of awareness / particularly performance
- **Can solve at-sea container transfer**

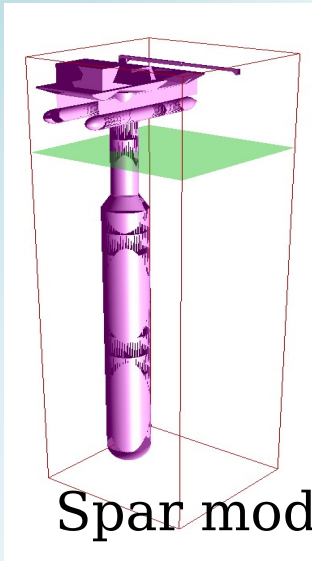


**FLIPSHIP
'flipping'**

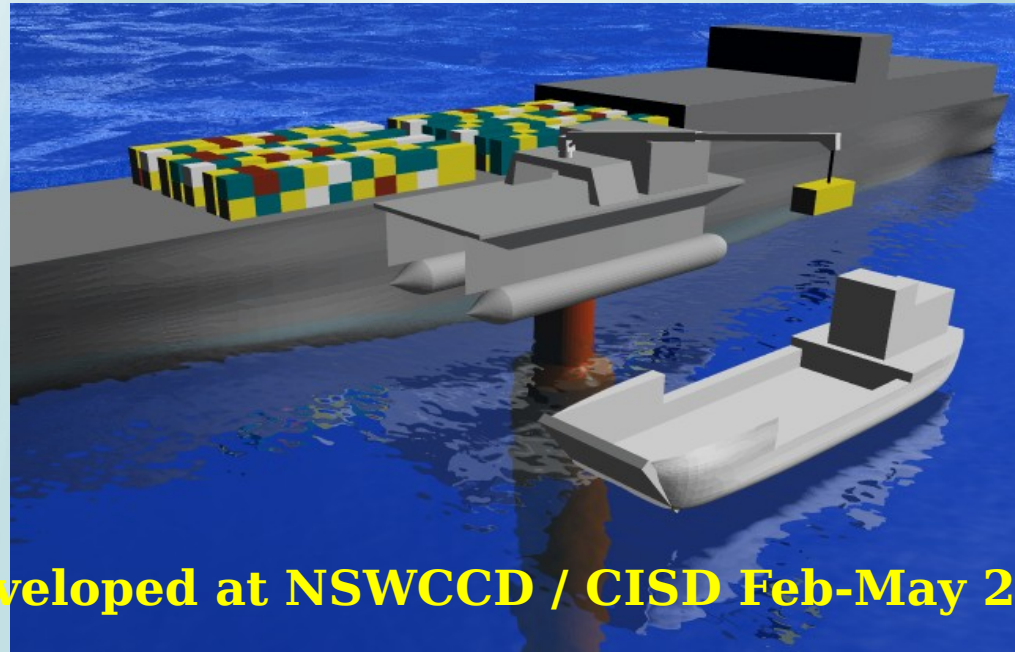




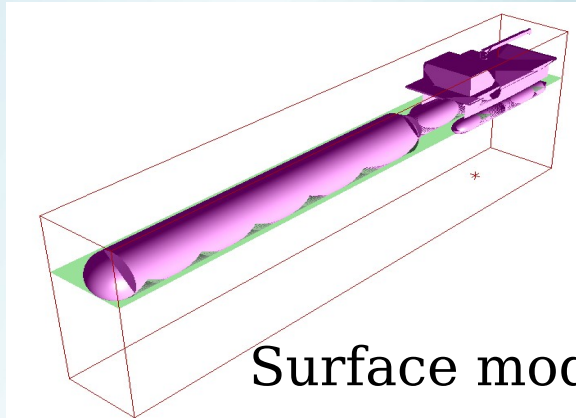
DWSC Concept Overview



Spar mode



Developed at NSWCCD / CISD Feb-May 2003



Surface mode

- Container transfer capability
- Detachable spar to increase utility in littoral
- Pendulation minimized & low motions
- 4 alternative seabasing uses (causeway, breakwater, DWSC, harbor crane)



Design Spiral

Produced 3D models, arrangements & animations

Resistance & powering (hullborne & sparborne) → **hence speed**

Identified propulsion

Selected machinery plant

Identified COTS crane

Synthesized catamaran craneship design

Stability assessment of craneship

Re-sized original Spar

Structural design of Spar → **structural weight**

Stability assessment in spar mode

Seakeeping

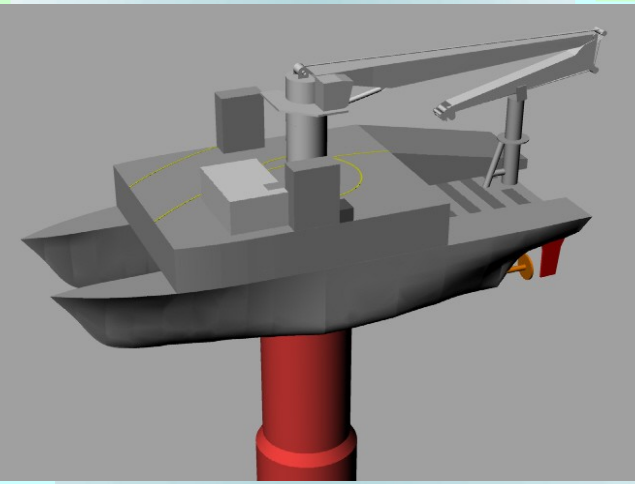
Spar shaping bow & upper surface

Updated resistance & powering predictions → **revised speeds**

Loadcases (hullborne & sparborne) → **size hinge & connectors**

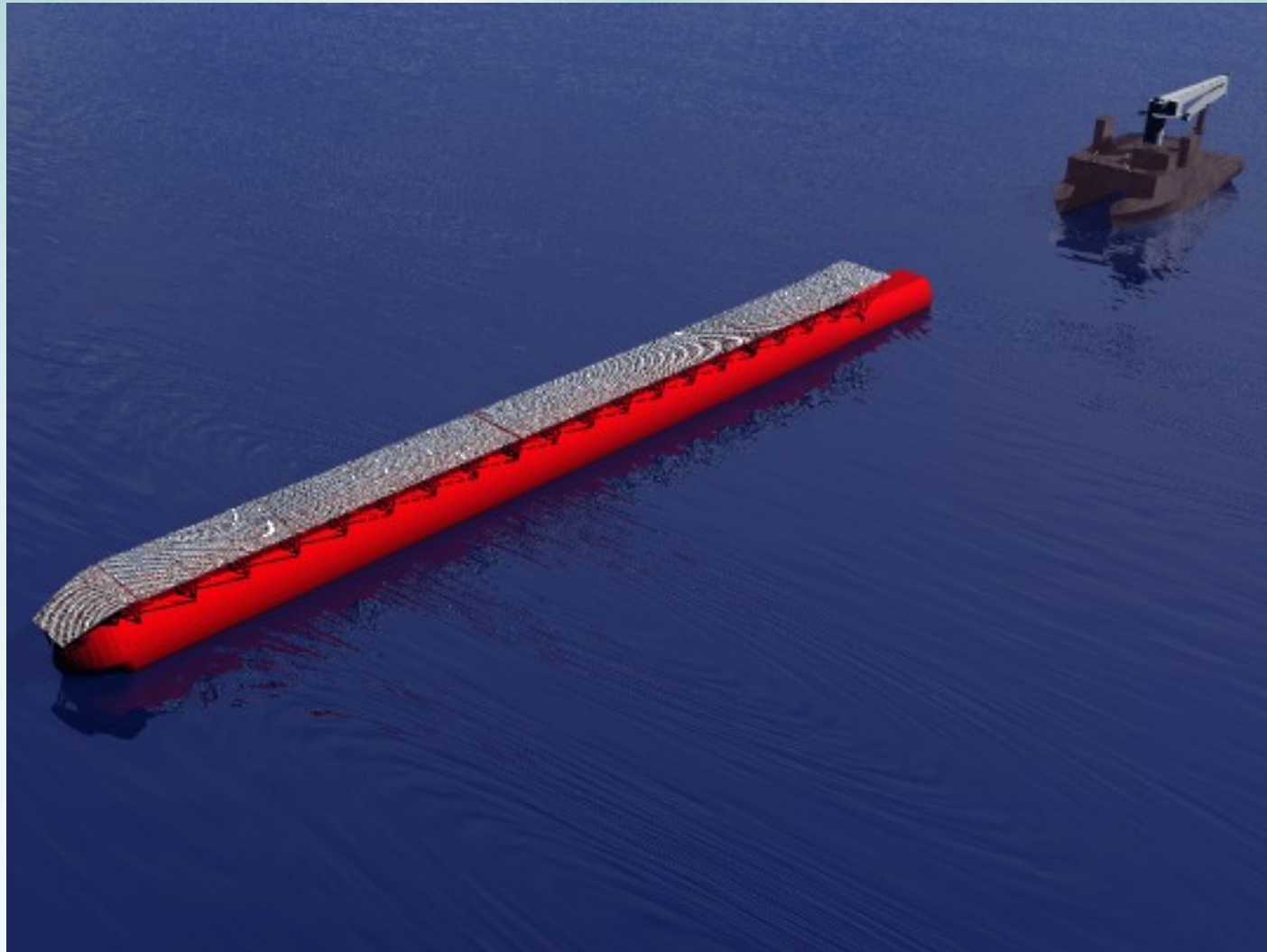
Determined spar operability worldwide (depth contours)

Developed alternative configurations / uses





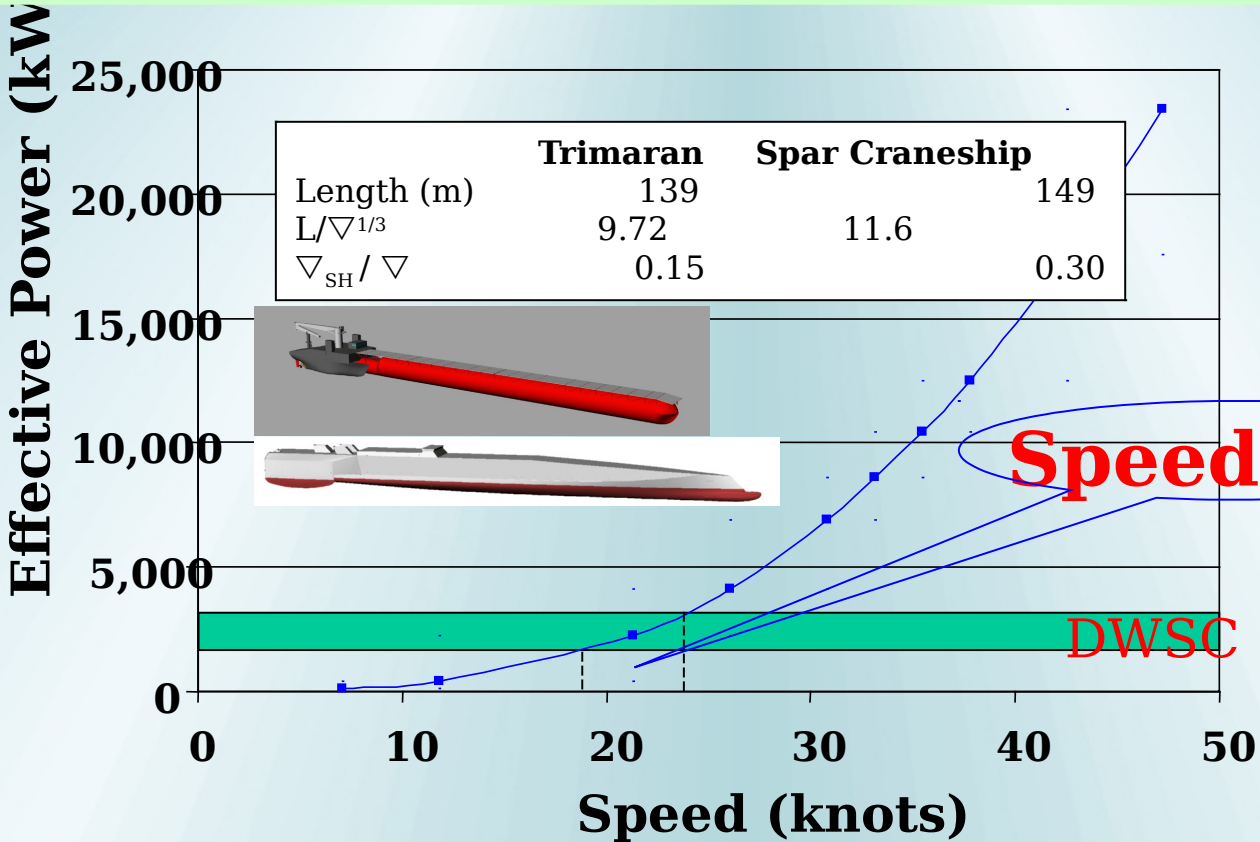
Animation





Powering - surfaced

Model test data for the High Speed Sealift Trimaran scaled to



Speed ~20 knots

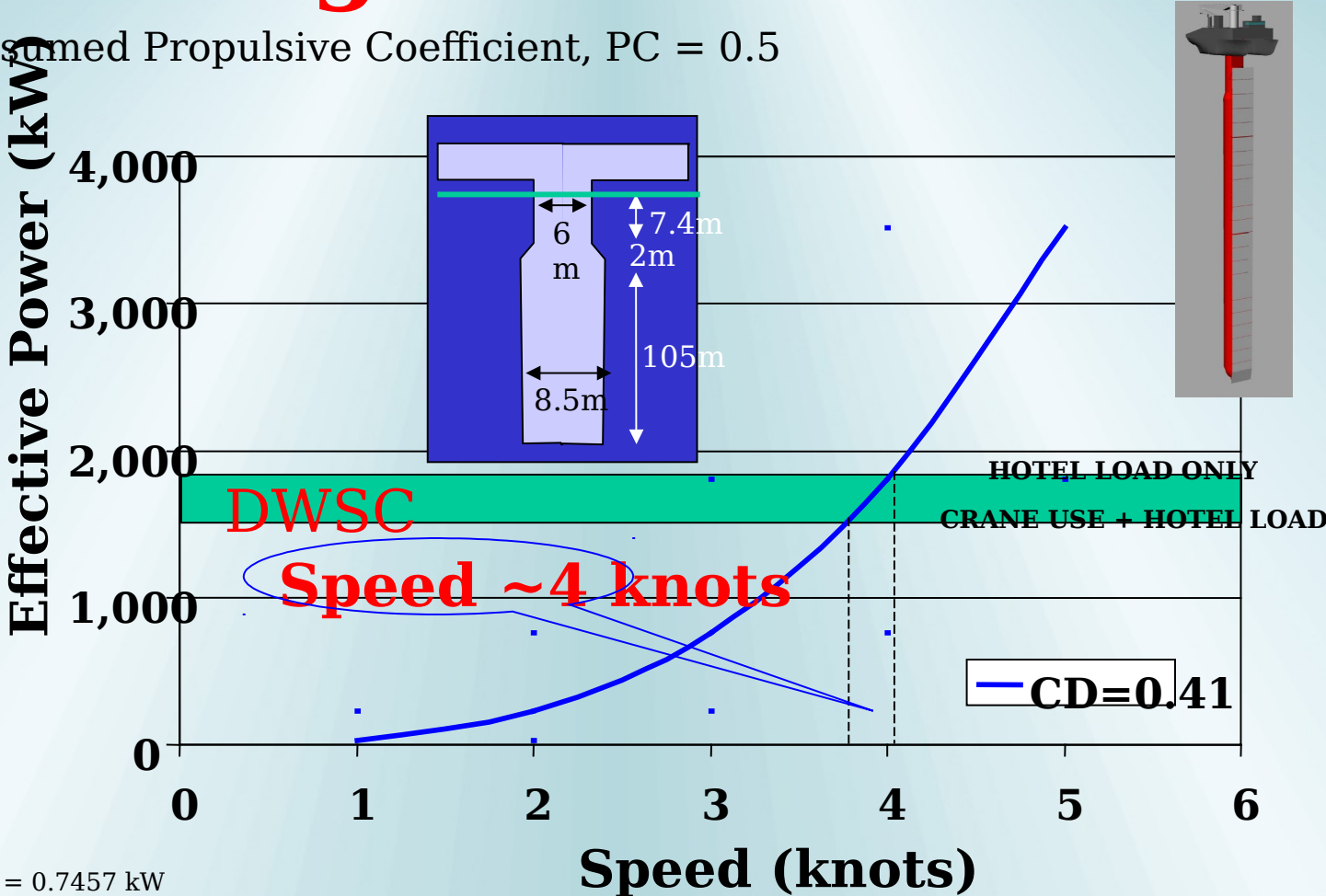
$Drag = frictional + residuary + correlation allowance$

1 kW = 1.341 hp or 1 hp = 0.7457 kW
 $L/\nabla^{1/3}$: Slenderness Ratio



Powering - vertical

Assumed Propulsive Coefficient, PC = 0.5



1 hp = 0.7457 kW
CD : Drag Co-efficient



Catamaran Design

Resistance & Powering predictions indicate 4MW of Installed Power would provide;

- ~20kts hullbo
- ~3kts sparbo



RV Triton's Integrated Propulsion Plant provide

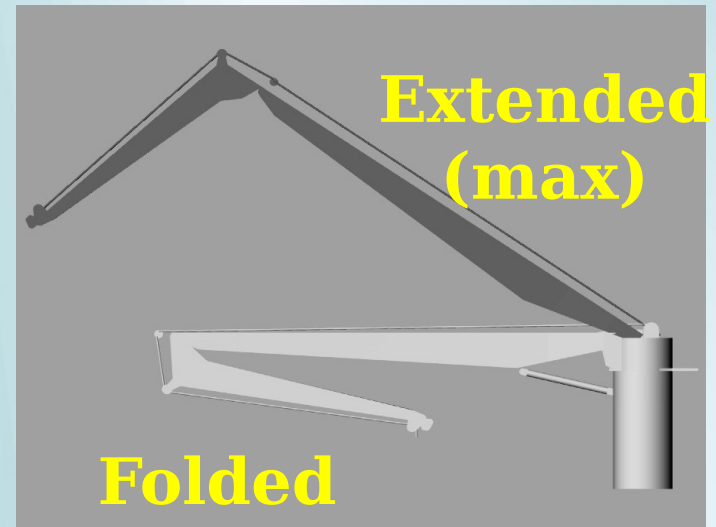
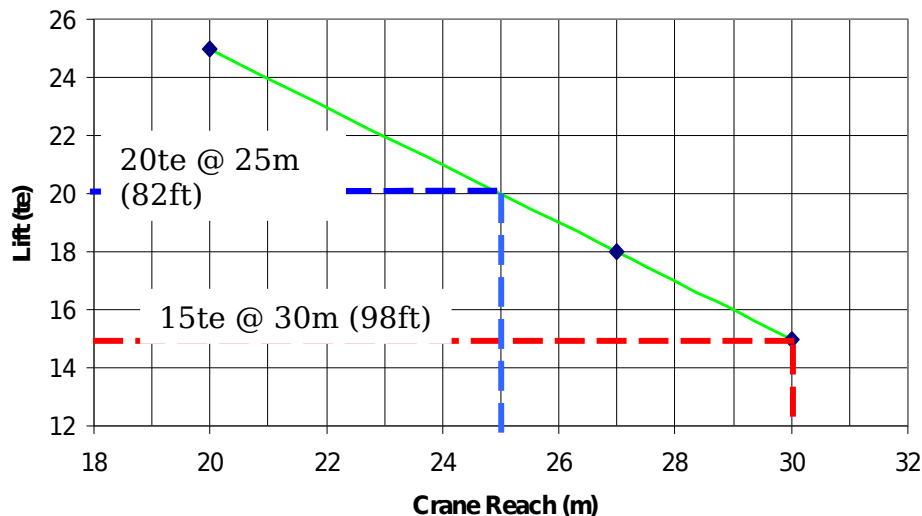
- 4MW of installed power
- Propulsion & electrical machinery weights



COTS Crane

- Hydralift Offshore Knuckle Boom Crane
- Weight (with pedestal) : 65.5 tonnes
- Power requirement : 235 kW

Lift versus Crane Reach



DWSC sized for 15te lift @ 30m (98ft) & max heel +/-2



Methodology - used existing vessels to de-risk catamaran sizing

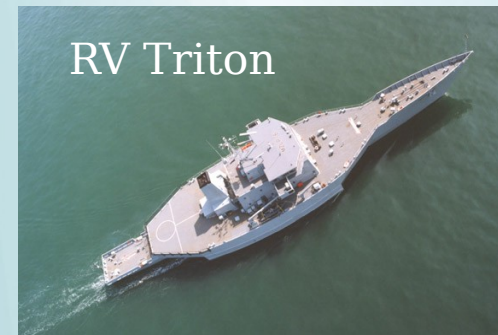
USNS Hayes (T-AGOR 10) - 5,000te Steel Catamaran

- Oceanographic research / towed array 'tug'
- Geometric scaling only



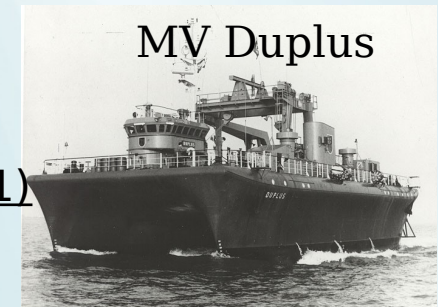
RV Triton - 1,116te Steel Trimaran

- Research vessel
- Weight scaling (SWBS groups 2-8)



MV Duplus¹ - 1,200te Steel Swath

- North Sea oil rig supply tender with central drilling rig
- Volumetric scaling for structural weight (SWBS group 1)



MV/RV - Merchant Vessel / Research Vessel

SWBS - Ship Weight Breakdown Structure

USNS - United States Naval Ship

SWATH - Small Waterplane Area Twin Hull

MWATH - Medium Waterplane Area Twin Hull

¹ MV Duplus later renamed MV Twindrill (modified to a MWATH : waterplane increased to improve stability during crane use)



Weight Summary

SWBS #	SWBS Group	Craneship	RV Triton	MV Duplus
1	Hull ¹	275.0	636.5	440.0
2	Propulsion	76.5	67.0	110.0
3	Electrical	116.0	114.9	
4	Control & Communications	9.2	9.2	
5	Auxiliary Systems	29.5	43.5	110.0
6	Outfit & Furnishings ²	77.8	142.2	90.0
7	Armament ³	0.0	0.0	0.0
8	Variable Load	65.8	102.3	450.0
9	Margins ⁴	0.0	0.0	0.0
LIGHTSHIP		584	1,013	750
FULL LOAD DISPLACEMENT		650	1,116	1,200

¹ Group 1 Hull - Steel construction

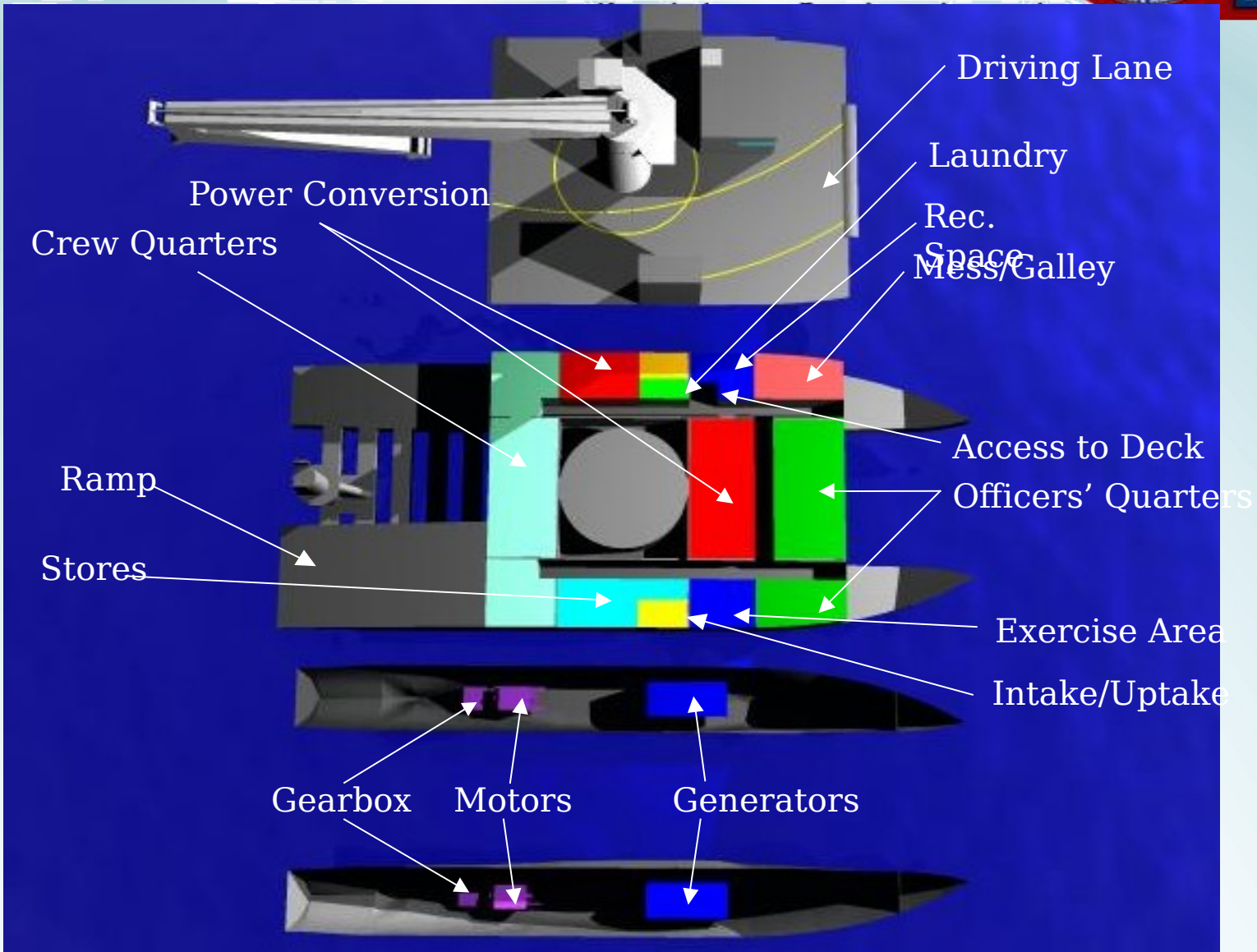
² Group 6 Outfit & Furnishings - Crew (3 officers + 8 rates)

³ Group 7 Armament - None fitted

⁴ Group 9 Margins - Assumed prorated over Groups 1-8

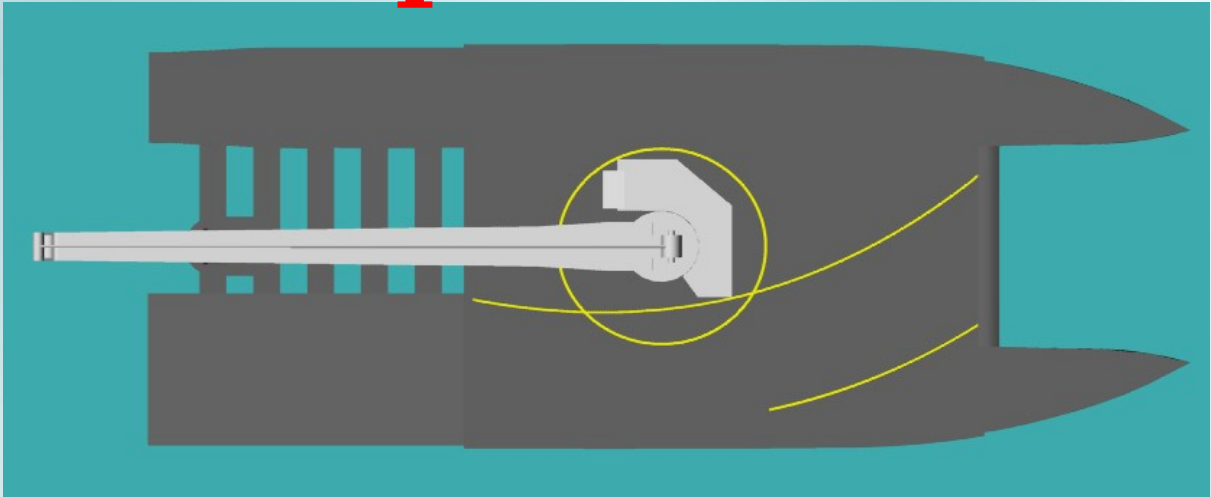
Units in metric tonnes

SWBS - Ship Weight Breakdown Structure

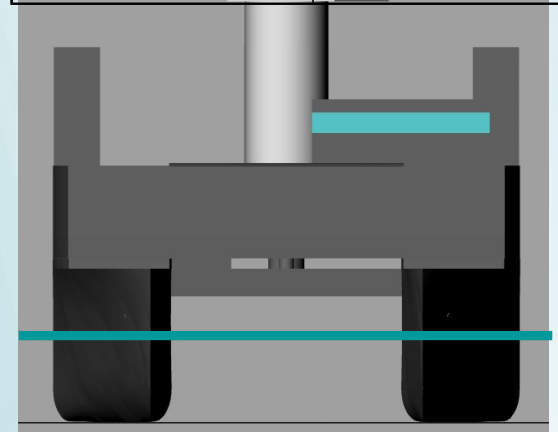
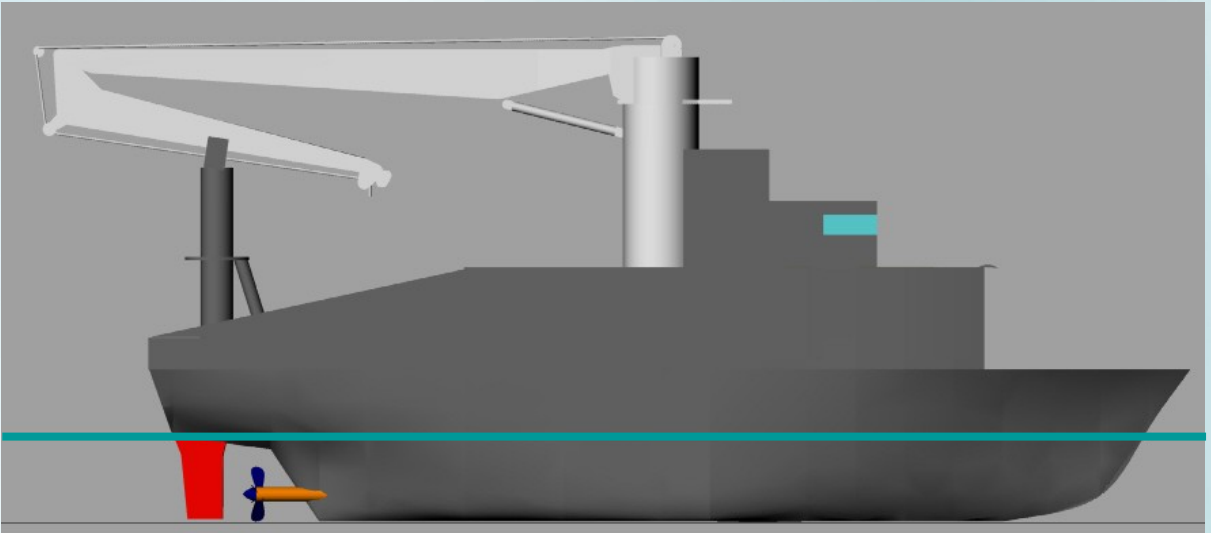




Principal Characteristics



Dimension	(m)	(ft)
Length Overall (LOA)	38.70	127.0
Beam (B)	15.75	71.7
Draft (T)	3.13	10.3
Side hull Beam (B _{SH})	4.00	13.1
Side hull separation	7.75	25.4
Wet Deck Clearance	2.87	9.4
Depth (D)	9.67	31.7
GMt	10.70	35.1
Air Draught (T _{AIR})	14.87	48.8
Displacement	650 te	





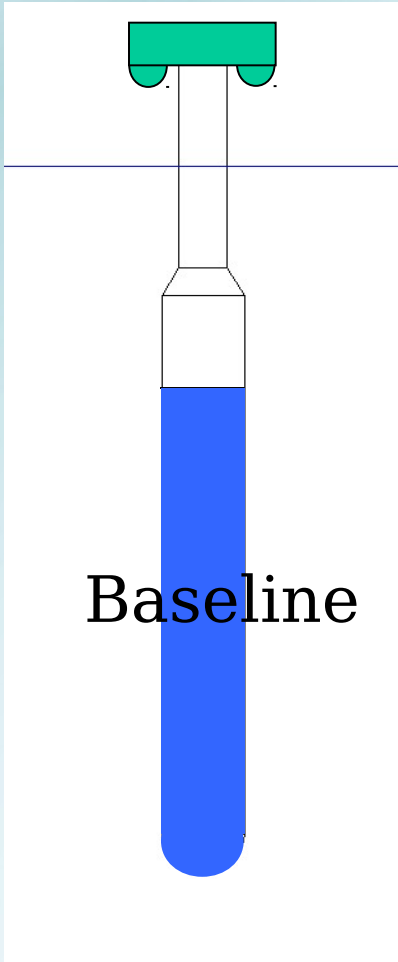
SPAR - Primary Design Drivers;

- **Top weight** → Catamaran weight
- **Crane lift requirements** → heel angle¹
- **Length/Diameter (L/D)** → structural strength
- **Pressure head** → structural weight

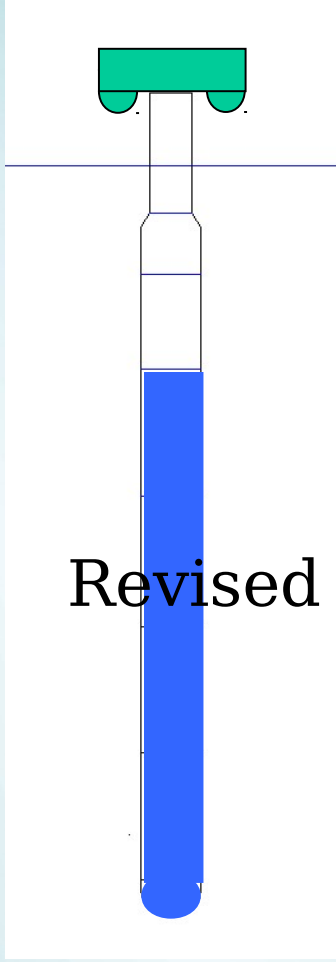
Other considerations;

- Sidehull separation
- Wet deck clearance / Draft of SPAR on surface
- Low waterplane area (for seakeeping)
- Resistance & powering
- Shape of bow / Upper surface (causeway)
- Integration of thrusters
- Interface with Catamaran (Hinge & Connectors)

¹ Heel angle during a 15te lift at 30m limited to +/-2.5 degrees



Baseline	Dimension	Revised
127.0	Length (m)	129.6
111.0	Draft (m)	118.0
11.9	Lower diameter (m)	8.5
6.9	Upper diameter (m)	6.0
16.0	Freeboard ¹ (m)	11.6
2,513	Structural weight (te)	1,220
8,000	Seawater ballast (te)	4,745
50.9	KB (m)	57.9
49.2	KG (m)	56.3
1.76	GM _T (m)	1.57
500	Catamaran weight (te)	650
11,013	Total Displacement (te)	6,615
	 Seawater Ballast	



¹ Freeboard here is the vertical distance from the waterline (in spar mode) to the wet deck of
KB : Vertical center of Buoyancy, KG : Vertical center of Gravity
GM_T is the Transverse Metacentric Height and is a measure of stability.
Both Spars were designed for a maximum heel of 2.5 degrees under a 15te lift at 30m whilst s

Draft (horizontal) =
2.4m
with 400te seawater ballast



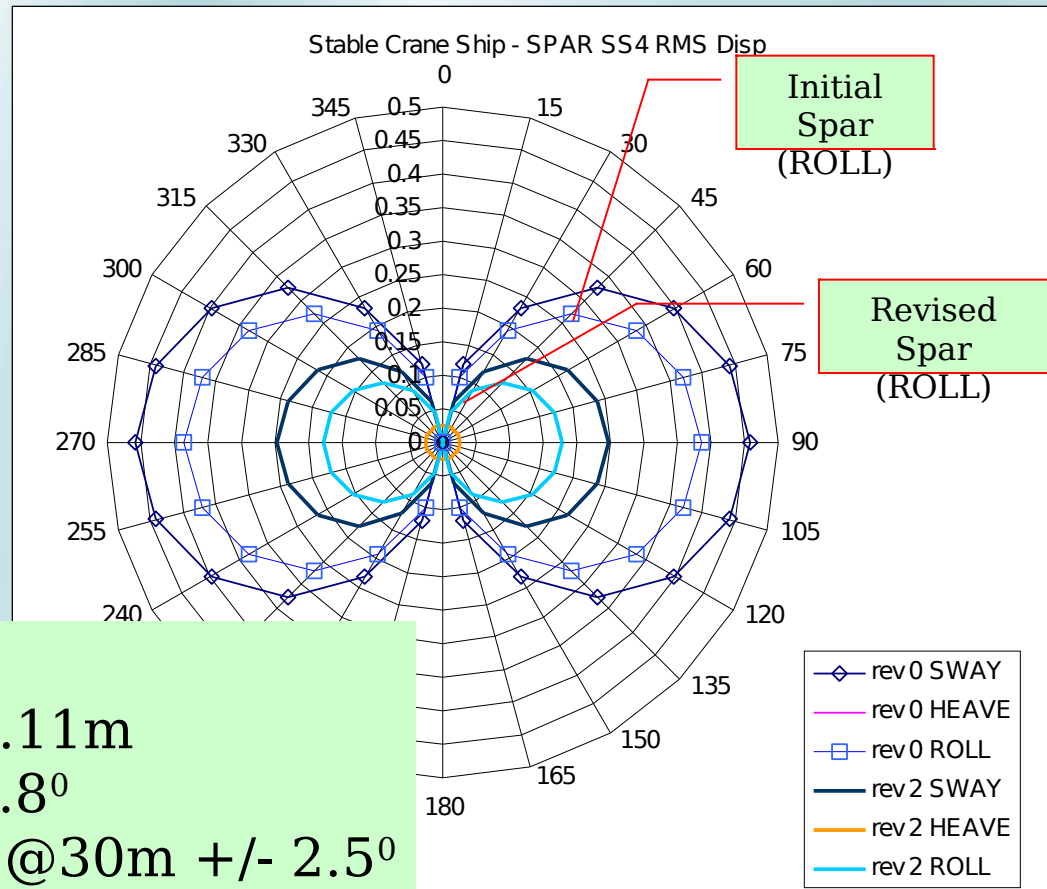
DWSC Seakeeping (Seastate 4)

SEASTATE 4

Max heave amplitude $\sim 0.11\text{m}$

Max roll/pitch angle $\pm 0.8^\circ$

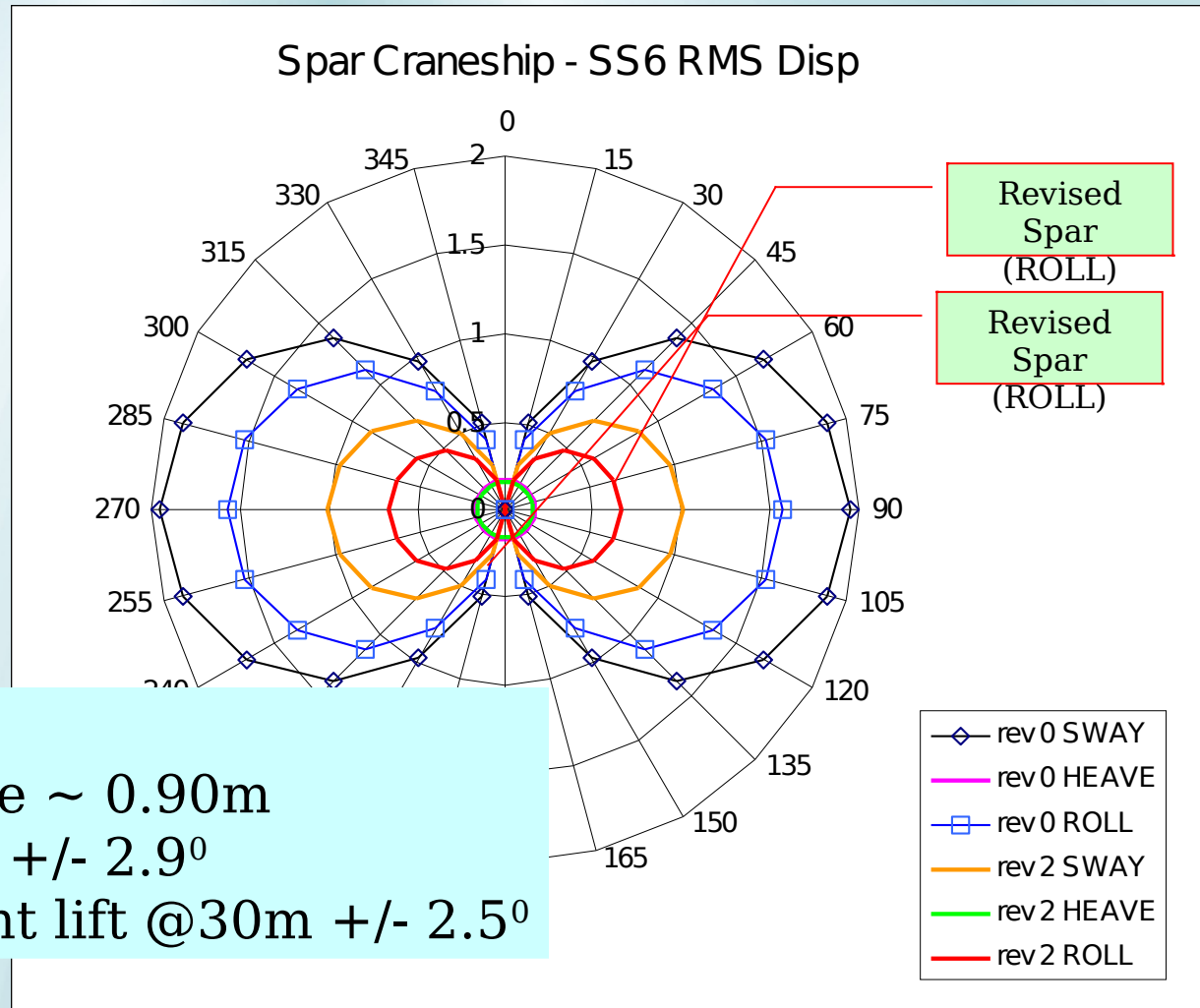
Max heel due to 15mt lift @30m $\pm 2.5^\circ$



Hence, MAX HEEL $\sim 3.3^\circ$ in SS4 with a 15mt lift



SPAR Seakeeping (Seastate 6)



SEASTATE 6

Max heave amplitude $\sim 0.90\text{m}$

Max roll/pitch angle $\pm 2.9^\circ$

Max heel due to 15mt lift @30m $\pm 2.5^\circ$

Hence, MAX HEEL $\sim 5.4^\circ$ in SS6 with a 15mt lift



Comparison of Natural Periods

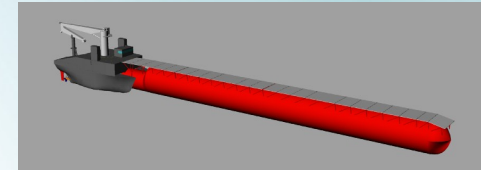
Platform	Heave	Roll	Pitch
LCU 2000	5.0	6.3	4.4
LMSR	8.4	20.4	8.2
Deep Water Stable Craneship (Initial)	34.8	131.5	131.5
Deep Water Stable Craneship (Revised)	30.5	148.8	148.8
Flipship	27.0	42.0	42.0

Displacement Summary (mt)

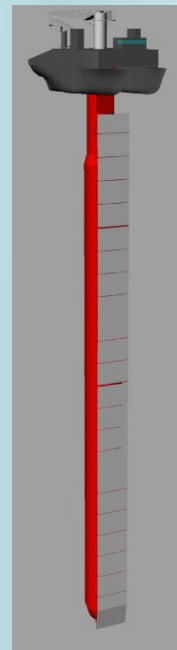
- LCU 2000
1,087
- LMSR
63,978



Connector Design -



SPAR-BORNE	
Catamaran athwartships bending	L
Torsional loading due to crane	L
List / heel angle loading	H
Mooring forces	L
Heave forces	L
LCG / TCG variation ¹	L
Thruster torque	L
Wind loading	L
Rogue wave - stern slam	H
Rogue wave - immersion	H



SURFACE-BORNE	
Wet deck stern-slam	H
Catamaran side-slam	H
Quartering sea loads	M
Roll bending	M
Collision / grounding	H
Deep ballast tension	L
Spar side-slam	M
Wave-induced bending	L
Propeller / thruster torque	L
Yaw	M
Maneuvering	L

L / M / H : Low / Medium / High

¹ LCG / TCG : Longitudinal and Transverse Centers of Gravity

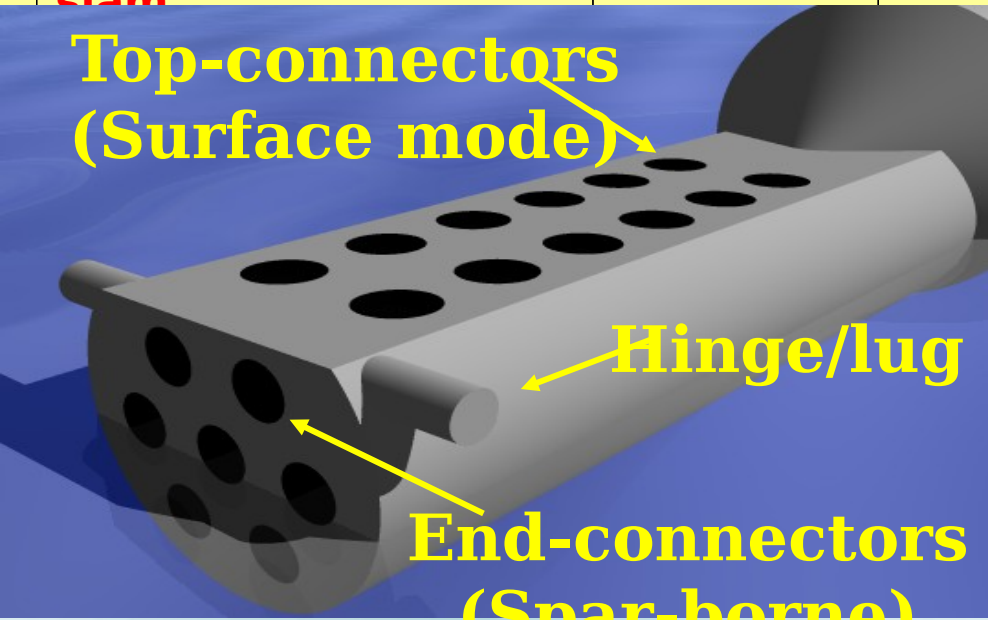
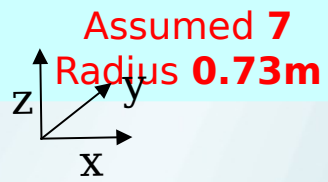


Connector Design - limiting loadcases

MODE	Loadcase	Force (ton)	Area req'd (ft²)
Surface	Collision (>10 sec)	611 [-x]	0.43
Surface	Catamaran side-slam	5,485 [+y]	3.69
Spar-borne	Rogue wave : stern-slam	3,619 [+z]	2.95

Spar-borne End-connectors

Area available 28m²
Area required 12m² (43%)
Factor of Safety of 4



Surface mode Top-connectors

Area available 45m²
Area required 15m² (33%)
Factor of Safety of 4

Assumed 12 Radius 0.62m



SPAR Operability : 200m depth

Arabian Sea contour Bangladesh



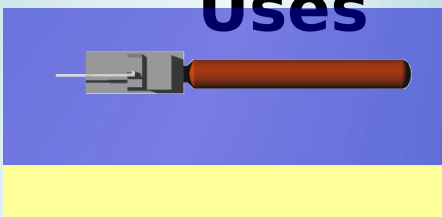
Shallow Water < 200m

Deep Water >= 200m

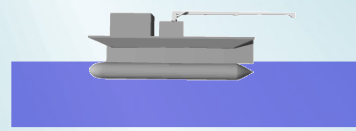
Source : National Imagery & Mapping Agency (NIMA) - World Vector Shoreline Plus (WVSPUS®)



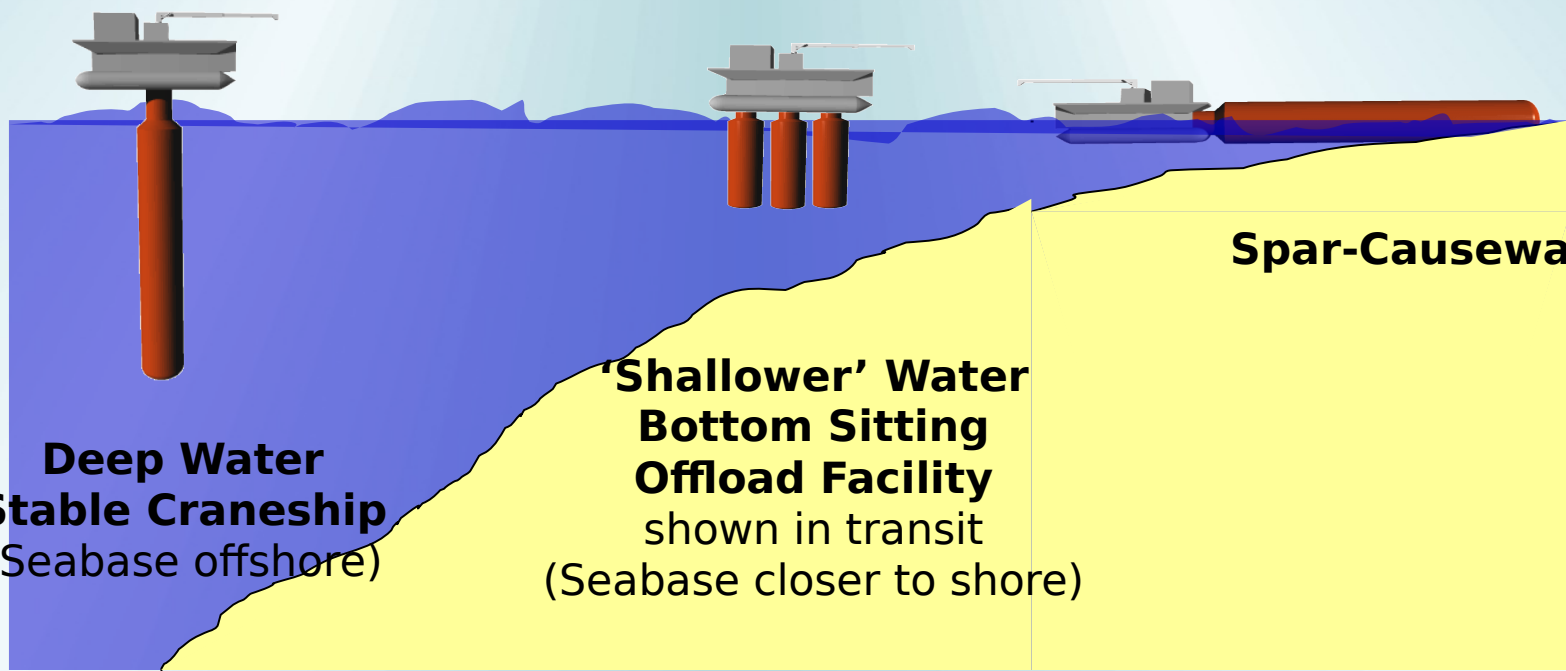
Spar Craneship : Alternative Uses



Rapidly Deployable Breakwater



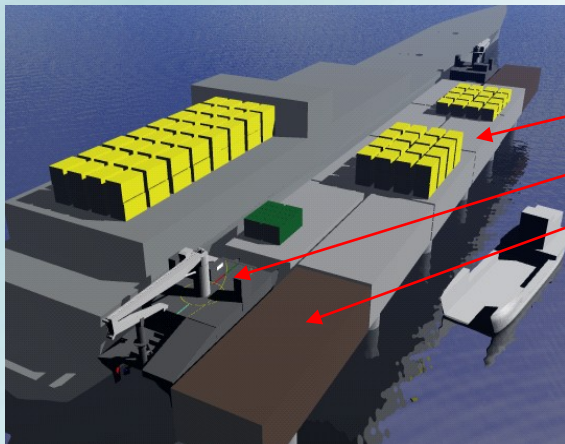
Harbor Craneship



Deep Water Stable Craneship
(Seabase offshore)

'Shallower' Water Bottom Sitting Offload Facility
shown in transit
(Seabase closer to shore)

Spar-Causeway



3 Modules;

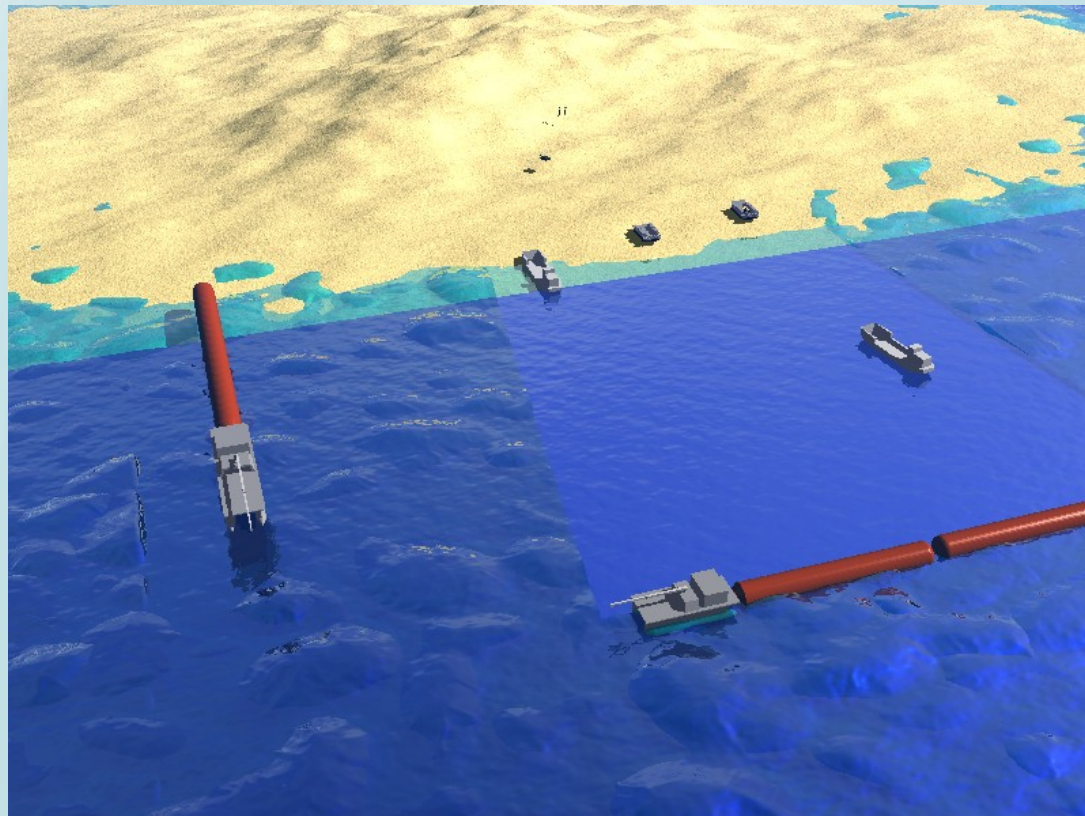
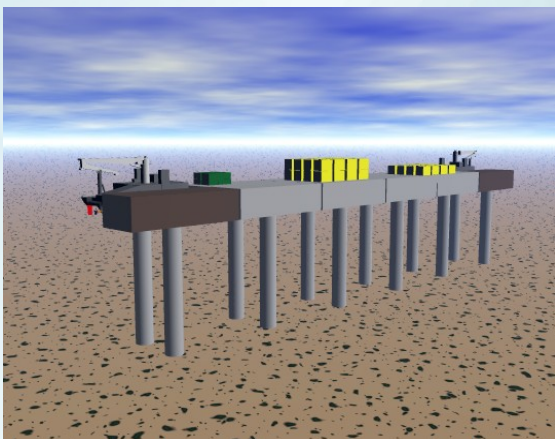
- Stowage
- Craneship
- Service

Deep Water Stable Craneship

- alternative uses

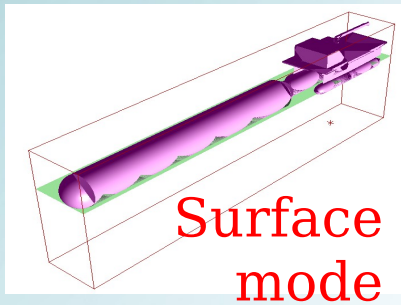
Bottom-sitting Offload Facility

- shorter 'stumpy' spars

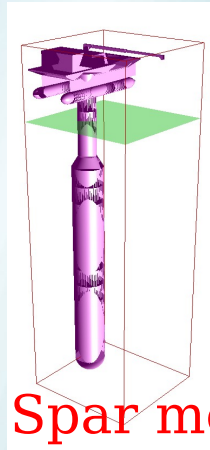




Deep Water Stable Craneship



Surface
mode



Spar mode

Military Benefit

- Extends crane transfer through SS5
- Pendulation minimized (>2minute roll period)
- Provides container transfer capability
- Reduces fleet wide craneage requirements
- Increases interoperability with commercial ships

Concept

- Spar and Catamaran craneship form trimaran
- Spar is detachable - providing useful craneship
- Self-propelled on surface & in spar mode
- ~20kts surfaced, ~4kts in spar mode
- Inspired by FLIPSHIP

Key Design Drivers

- Connectors
- Hinge
- Speed on surface and in spar mode
- Control during ballasting
- Stability
- Seakeeping
- Draft / depth of water



De-risking to date

- Revised/refined design of;
 - Spar
 - Catamaran Craneship
- Sizing of hinge and connectors
- Shaping for powering and other uses
- Visit to FLIPSHIP to 'FLIP'
- Worldwide Operability
- Stability & Seakeeping

Further Work

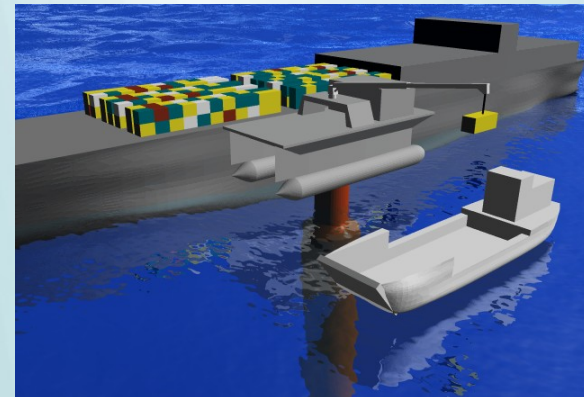
- FAU Design, Build & Test 1:15 scale demonstrator
- De-risk Key Design Drivers

Alternatives;

- Re-fuelling Lily-pad
- Special Forces Operating Base
- FLIP II (Craneship Critical Technology Demonstration)

Status

- Identified Design Drivers
- Quantified performance in a credible seabased scenario



We aim to demonstrate....

Spar Technology has superior seakeeping



FAU Ocean Engineering Dept

- **Design, Build & Test a 1:15 scale Demonstrator**
- **No crane**
- **Unmanned (for safety)**
- **Self-deploying**
- **Working ballast system**
- **Partial funding from ONR**
- **Project Advice from CISD**
- **Critical Design Review : complete 01-Dec-04**
- **Construction started end January**
- **At-sea testing mid-April 2005**
- **4 Teams (Catamaran, Spar Structure, Ballast and Control Systems)**



QUESTIONS